The Transit of Ions in the Electric Arc.

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According to the most modern view, as enunciated by Professor J. J. Thomson in one of his recent works,* the phenomenon known as the Electric Arc is explained on the assumption that the positive and negative electrodes emit respectively positively and negatively electrified corpuscles or ions, which, under the influence of electric repulsion, travel across the space occupied by the arc and bombard the electrode opposite to the one from which they have been emitted. It is further supposed that the electric current is itself conveyed by these ions, and that the high temperature of the electrodes is produced by their bombardment.

About a year ago it occurred to the writer that it should be possible to test the correctness of, at any rate, some portion of this theory by deflecting—by means of a magnet—either the positive or the negative ions into a Faraday cylinder placed with its aperture just touching the centre of the arc, in a manner somewhat similar to that adopted by Perrin,† for demonstrating the electric charge carried by cathode rays. The experiment was tried, but it was found that no definite results could be obtained, owing to the erratic behaviour of the arc, which proved very unmanageable, and preferred to divide itself into two arcs between the carbon electrodes and the exterior of the Faraday cylinder, which was rapidly destroyed by fusion.

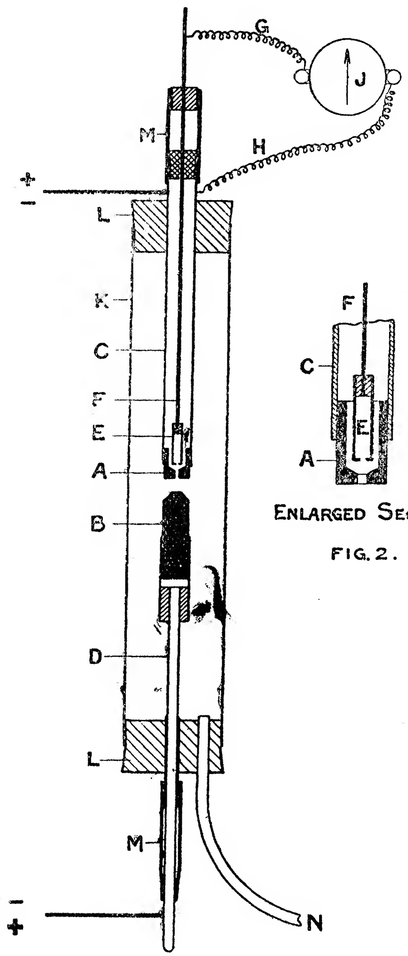
More recently the writer has made the experiment again in a somewhat modified form, and has obtained results which appear to prove conclusively that the theory, as above described, is correct, and that positively and negatively charged carriers do actually travel from the positive and negative electrodes respectively along the arc in opposite directions, and do bombard the opposite electrodes.

The apparatus is shown in section in fig. 1, in which "A" and "B" are two electrodes of ordinary arc-lamp carbon. The upper electrode, "A," is fixed rigidly in one end of the fixed brass tube, "C," while the lower electrode, "B," is held in a similar tube having a sliding arrangement at "D," whereby it can be slightly moved so as to bring the carbons into contact for the purpose of striking the arc.

* 'Conduction of Electricity through Gases,' 1903.

† 'Comptes Rendus,' vol. 121, p. 1130, 1895.

A small hole is pierced axially through the upper electrode, and immediately behind this aperture is fixed the insulated Faraday cylinder, "E," which has its aperture in line with, and facing, the aperture in the electrode. By means of an insulated brass rod, "F," and the conductors,



SECTION
FIG. 1.

ENLARGED SECTION
FIG. 2.

"G" and "H," any difference of potential between the Faraday cylinder and the upper electrode—which, with the brass tube, "C," completely encloses the cylinder—can be measured by means of the mirror galvanometer, "J." Fig. 2 shows an enlarged section of the Faraday cylinder and the pierced electrode.

Current for the experiments was obtained from the 200-volt continuous-current public supply, resistances being inserted in the circuit so as to keep the current down to about 3 ampères with some 50 volts across the arc.

The first experiments were made with the apparatus in air at ordinary atmospheric pressure. Under these conditions no results were obtained. Having regard to the small velocity that the ions could have under the comparatively small potential difference across the arc, the considerable distance the ions would have to travel in order to enter the Faraday cylinder, and the density of the air at ordinary atmospheric pressure, this was to be expected.*

The apparatus was next enclosed in the glass tube, "K," with rubber stoppers, "L," at the ends, the moving parts being rendered air-tight by the rubber tubes, "M." By means of the tube, "N," the whole was connected to a mechanical air-pump capable of giving moderate degrees of vacuum.

With a very small degree of exhaustion—about half an atmosphere—it was found that if "A" were made the positive and "B" the negative electrode, immediately the arc was started a positive electric current, passing from "A" to the Faraday cylinder, and showing that the latter had become negatively charged, was indicated by the galvanometer.

As the exhaustion proceeded, this current was found to increase, and at a still moderate degree of exhaustion, on reversing the current in the arc, and making "A" negative and "B" positive, it was found that the positive current, through the galvanometer, passed from the Faraday cylinder to "A," showing that the cylinder was positively charged.

In each case these results were obtained with degrees of exhaustion at which the arc still retained its normal characteristics, while the fact that the effects were only produced when the arc played on the upper electrode so as to cover the aperture, no deflection of the galvanometer taking place when the arc was deflected by means of a magnet, so as not to cover the aperture, showed very clearly that the electrification of the Faraday cylinder was due to ions passing from the arc through the aperture. This was also proved by plugging the aperture in the electrode with a small piece of carbon. When so plugged, no deflection of the galvanometer could be obtained.

Whether the electrode "B" were made positive or negative, it was found that the galvanometer deflections increased considerably with the degree of exhaustion, while, at any given degree of exhaustion, a considerably

* Since this paper was communicated the writer has succeeded, by employing larger arcs of from 10 to 12 ampères, and by slightly enlarging the aperture in the upper electrode, to obtain all the results described in air at ordinary atmospheric pressure.

larger deflection was obtained when "B" was made negative than when it was made positive. These results correspond with the known fact that negative ions have a greater velocity than positive ions.

As was to be expected, having regard to the unstable nature of the arc, the galvanometer deflections were not very steady. They were, however, invariably in the directions indicated, according as the polarity of the electrodes was transposed, and endured as long as the arc covered the aperture in the upper electrode.

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The Accurate Measurement of Ionic Velocities.

By R. B. Denison, M.Sc., Ph.D., and B. D. Steele, D.Sc.

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(Abstract.)

The value of the direct method of measuring ionic velocities has been seriously diminished in the past by the necessity of using gelatine solutions in the measuring apparatus, and by the restriction of the method to more concentrated solutions.

The authors have succeeded in devising an apparatus in which it is possible to compare and measure the velocities of the ions of a given salt without using gelatine or other partitions during the actual experiment; and they have also succeeded in extending the method to the measurement of dilute solutions.

The apparatus consists of two reservoirs, each supplied with a special electrode vessel, and of a measuring-tube of known cross-section, in which the solution to be measured is placed. One of the reservoirs contains a solution of a salt which has a slower cation than that to be measured, and the other a solution of a salt with a slower anion than that to be measured. When a current is passed in the proper direction through such a system, an electrolytic margin of constant velocity is formed, provided certain conditions are fulfilled. These conditions have been already described.* The measuring tube is provided at each end with a parchment-paper partition, which facilitates the formation of a sharp electrolytic margin between the indicator

* Masson, 'Phil. Trans.,' A, 1899, p. 331; Steele, A, 1902, p. 105.